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Quantum Mechanics : Foundations and Applications

(Texts and Monographs in Physics, 3rd edition)

by Arno Bohm

Springer-Verlag : Berlin-Heidelberg-New York-London-Paris-Tokyo-Hong Kong (2001)

xix + 688 pages, 96 figures; price : DM 149.69, SFR 128.94, GBP 51.50, US $ 69.95 (soft cover); ISBN 0-387-95330-2

The book is the third edition of a text first published in 1979. The subsequent editions, and in particular, this edition itself, has now become popular. In our opinion, this book will be most useful for the students who have finished a usual university quantum mechanics course, and now want to start research in atomic and molecular physics.

There are already a large number of quantum mechanics books in the market, covering basically the same standard material, perhaps approaching them from slightly different angles. Any textbook on quantum mechanics should certainly start with explanations of the basic principles and abstractions so characteristic of the subject and the mathematical tools through which the quantum observables are made to correspond to abstract entities.

This book, in its first chapter covers only the mathematical preliminaries. However, its distinguishing feature is that during the discussion of the formal principles and techniques, the observational contexts are always brought to the forefront. The reader is guided from the abstractions to the real world of atoms and molecules, where the mathematical formulas emerge to be intimately related to real life experiences. Thus in Chapter 2, the physical meaning of the very abstract postulates of quantum mechanics has been clarified by showing them in action on a concrete physical system, the harmonic oscillator in this case. The application of the postulates to a continuous spectrum and a discussion of wave particle duality on its basis constitutes another nice section in this chapter.

There are ample discussions of atomic and molecular physics topics generally left out of conventional courses. An example is provided by the chapter on vibrational-rotational spectroscopy of a diatomic molecule (Chapter 3), which illustrates nicely some principles of angular momentum algebra. The whole of Chapter 7 is devoted to the energy spectrum and wavefunction of the alkali atoms. In Chapter 8, the resolvent operator method has been shown to provide a unified framework for dealing with perturbation of the discrete and continuum states. This method is extensively used in recent research and has yielded many fruitful insights into high order bound-continuum transition amplitudes. Again, in Chapter 11 the simplest 2-electron bound system, the He atom, has been used to illustrate the Fermionic symmetry property as well as the angular momentum algebra and the correlation of the theoretical results with experimental spectroscopic data have been clearly brought out. The interesting and important observations relating to doubly excited states are mentioned and discussed. Another example of this kind of physical approach is found in the discussion of the concept of parity and its importance in molecular spectroscopy in Chapter 3. Chapter 13 also gives a short introduction to Bell's inequality and cites the results of the famous experiments of 1982 confirming the original quantum view.

The second half of the book is mainly concerned with quantum scattering theory, though the last two chapters deal with somewhat different topics. No less than seven chapters have been devoted to different aspects of scattering. Together they should constitute an adequate introduction for starting researchers on atomic or nuclear scattering. As in other chapters of the book, the treatment is lucid. The general description of collisions based on basic quantum mechanical quantities rather than the intuitive time independent approach has been adopted from the beginning. It has been demonstrated how this approach, in its turn, allows us to derive cross section formulas for very general physical situations. The partial wave amplitudes arise from the formal theory through the Lippmann Schwinger equation and the definitions of the S and T matrices. Other chapters are concerned with time reversal invariance and detailed balance, line shapes for single and double multichannel resonances with experimental evidence from nuclear physics and decaying quantum systems.

The last two chapters, added in the third edition, are quite advanced and are on the borderline of modern research topics. They deal with quantum phases. In 1983 M V Berry discovered that a phase factor, which was thought to be unimportant could play important role in certain types of evolution of a quantum system. The literature of the late 80's and much of the 90's was full of papers exploring the implications of Berry's phase. The penultimate chapter explains the concepts of geometric and dynamic phases by considering adiabatic cyclic evolution of systems where a parameter dependent Hamiltonian changes slowly with time due to the change of the parameter. Finally in the last chapter the author nicely introduces the basic principles of a gauge theory. Then he goes on to show that the molecular wave functions fulfill these abstract relations under the gauge transformation defined on the unitary matrices depending on the separation parameter and derives various corrections to simple molecular wave functions.

This book is a very clearly written advanced quantum mechanics text stressing atomic molecular, and to some extent, nuclear physics topics to illustrate the formal structure. In the epilogue the author mentions the limit of the purely reductionist approaches as implied by the algebra of quantum operators. He stresses the fact that in a quantum physical system combination of the simpler structures of the irreducible subspaces may not adequately describe it as a whole.

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Space Plasma Physics

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viii + 329 Pages, illustrated; price : Rs. 450.00 (Hard Cover)
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Plasmas are ubiquitous in the universe and therefore a thorough understanding of the universe requires a complete knowledge of the properties of plasma. The present book is an welcome addition to a large number of books already existing in this subject. This book is broken into two parts : in Part I, the basics of plasma physics are discussed while in Part II, generally solar physics, solar wind, planetary magnetosphere *etc.* are discussed.

In the Part I itself, the author has made a great deal of effort to prepare the basics of the subject such as the definitions of Debye shielding, single particle motion in a magnetic field, *etc.* which M. Sc. students would have normally read in their course on electrodynamics, for instance. Some more preparatory matter, such as Boltzmann equation, fluid description of fluid dynamics, basics of the magnetohydrodynamics (MHD), Alfven wave equation, dispersion relation *etc.* have also been included for the sake of completeness. Thus, up to eight Chapters (82 pages of the book consisting of 329 pages), the author recapitulates very basics of the subject. This is not necessarily unwanted since the students would become used to the style of presentation and notations while giving a quick reading of these initial Chapters. In Chapters 9 and 10, the author discusses the waves in the unmagnetized and the magnetized plasma and derive the respective dispersion relations. In the subsequent Chapter the plasma instabilities under linear perturbations, such as Rayleigh-Taylor, two-stream instabilities are discussed. In presence of finite amplitude perturbations, when the balance between the wave non-linearity and the dispersion takes place, solitary waves are formed and these are discussed in Chapter 12. In the final Chapter of Part I, the kinetic theory of the waves and instabilities, resonance interactions between the waves and the particles leading to Landau damping have been considered.

The Part II of the book starts with the basics of the solar activity and solar winds. In Chapter 2, a great deal of discussion is made about the interaction between the solar wind with the planetary magnetosphere, the processes of magnetic re-connection in magnetotail, evidences of reconnections, observations of plasmoids *etc.* Chapter 3 goes in extraordinary details of phenomena occurring in the Earth's magnetosphere. Convection in the magnetosphere and its coupling with the ionosphere are also discussed in this Chapter. In Chapter 4, the properties of the radiation belt, magnetic mirroring *etc.* are discussed. In Chapter 5, the study of naturally occurring radio waves in earth's magnetosphere such as whistlers and VLF emissions is presented. Detailed theoretical work on the propagation of these waves is also presented. A general discussion on the parametric instability in ionospheric plasma and occurrences of striation are discussed in Chapter 6. The Chapter 7 is dedicated to three other inner planets, *i.e.*, Venus, Mars and Mercury. Venus and Mars do not possess any intrinsic magnetic field and therefore the solar wind directly hits these planets. They also have ionospheres. Mercury has a weak field and therefore the magnetosphere is distinct. The last Chapter of Part II, namely Chapter 8 deals with the outer planets all of which

have intrinsic magnetic fields. A brief discussion on the magnetospheres of these planets, though qualitatively, has been made.

The overall book does cover quite a lot of plasma and space physics. Perhaps some discussions on radar observations, magnetospheric-ionospheric-thermospheric coupling, airglow could have been made. One could have also introduced the importance of the numerical simulations which are carried out in this subject. This would have given the students an excellent opportunity to understand what space physicists normally do when they face very complex situations.

The language of the book does not seem to be very lucid, and indeed, is full of errors. In many sentences the articles are missing, a common error by many Indian authors. Discussions which would have been otherwise continuous have been unnecessarily broken into numerous paragraphs. Begining and ending of paragraphs are occasionally abrupt. There are no punctuation marks after the equations, which are generally thought to be continuations of the sentences. The two Parts of the book are not separated by any title page. So the readers suddenly see Chapter 1 starting right after Chapter 13. Some of the figures have the appearances of being 'hand drawn'. These could have been improved. However, given that the price of the hard bound volume has been kept well within the limits of the students, the author has done a very good job and this low priced book is worth having in the personal collection as well as in science libraries.

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